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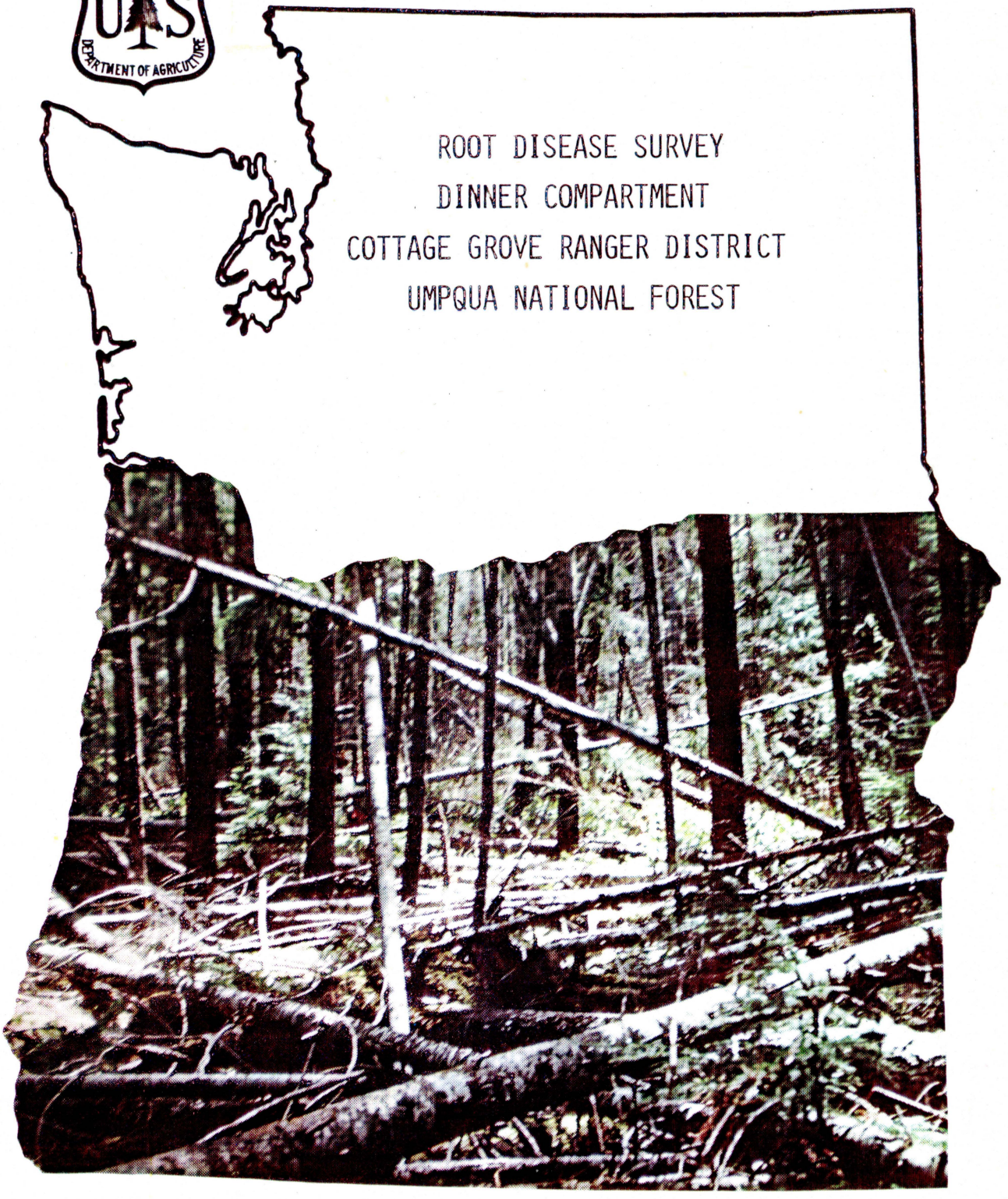
Forest Pest Management
Pacific Northwest Region

ROOT DISEASE SURVEY
DINNER COMPARTMENT
COTTAGE GROVE RANGER DISTRICT
UMPQUA NATIONAL FOREST



September 1982

Root Disease Survey
Dinner Compartment,
Cottage Grove Ranger District
Umpqua National Forest, Oregon

by

Craig L. Schmitt, Pathologist
Alan Kanaskie, Biological Technician
Pacific Northwest Region
Forest Pest Management
USDA Forest Service
Portland, Oregon

Introduction

On May 18 and 19, 1982, Forest Pest Management personnel did a disease survey of 99 acres within the Dinner Compartment Cells 92, 96, and 112 (T. 21 S., R. 1 E., sec. 28 W.M.) on the Cottage Grove Ranger District, Umpqua National Forest (Figure 1). The purposes of the survey were to determine disease losses and identify problem areas and pathogens responsible in order to develop management strategies for these cells.

There are two distinct stands within the survey area. One stand, the largest, is predominantly Douglas-fir *(Pseudotsuga menziesii)* which was planted in 1955 following clearcutting and burning. Some naturally seeded western hemlock *(Tsuga heterophylla)* and western redcedar (*Thuja plicata*) are also present as is red alder (*Alnus rubra*), the latter mainly in creek bottoms. This stand was precommercially thinned when it was approximately 15 years old. The second, smaller stand makes up the southern lobe of the survey block. It is approximately 40 years old, and appears to have regenerated following a fire. Species composition is similar to the younger stand, but this stand has not been thinned. Both of these stands are tentatively scheduled for commercial thinning in 1995.

Methods

Survey Procedure

A systematic survey of the entire 99-acre block was accomplished by placing variable radius plots (BAF 20) at 2-chain (132') intervals along transects located 4 chains apart. Each plot was inspected for dead, dying, or symptomatic trees with root diseases. Data recorded for such trees were species, diameter breast height (DBH), dead or alive, and pathogen(s). Every fifth plot was a count plot where all trees (including healthy) were tallied by species, DBH, and condition (live, dead, standing, down). Heights were measured on a subsample of plot trees across DBH size classes.

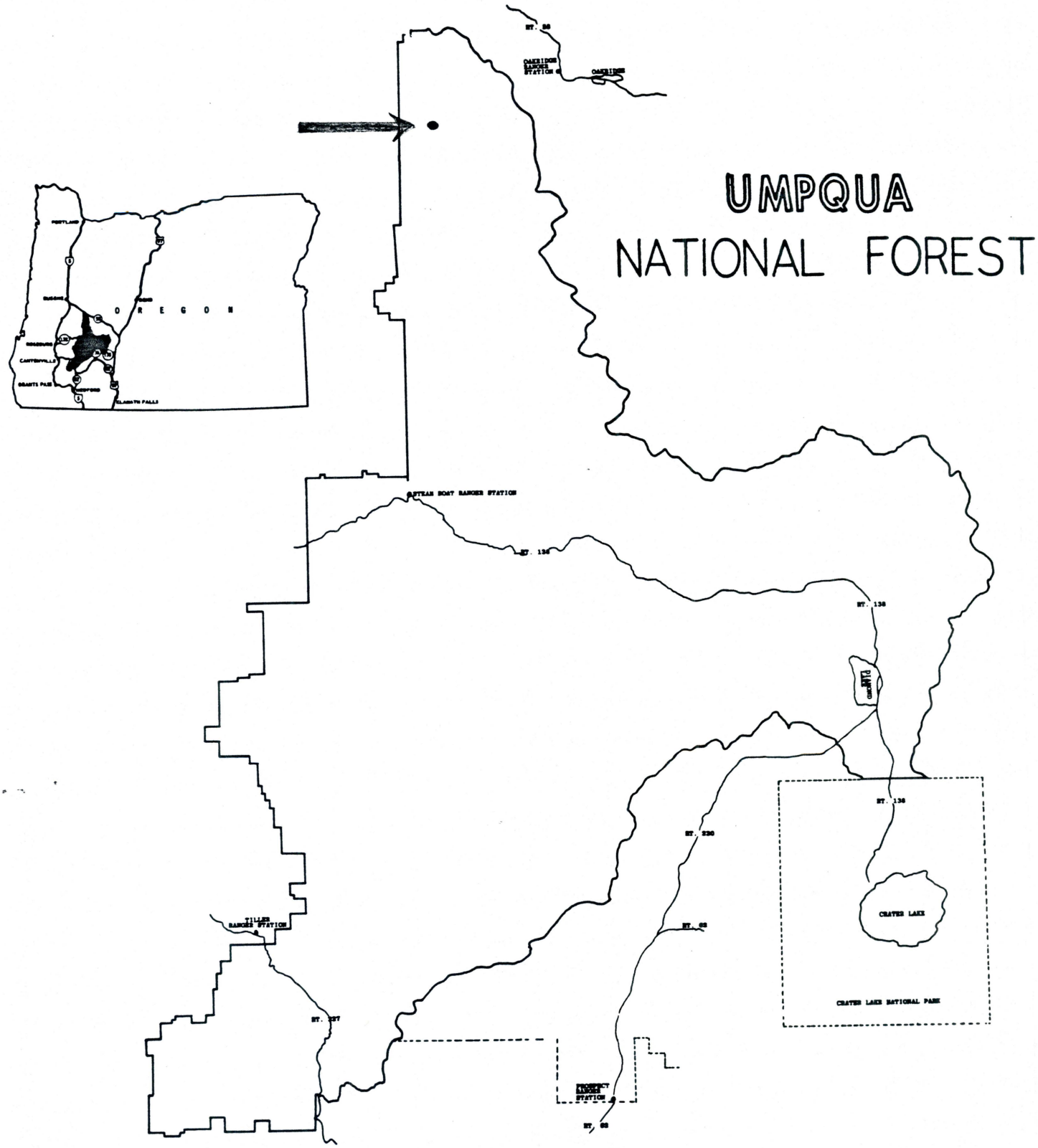


Figure 1. Map depicting location (arrow) of the survey area (Dinner Compartment-Cells 92, 96, 112), Cottage Grove Ranger District, Umpqua NF

Surveyors traveling along transects looked for diseased trees or infection centers within 2 chains of either side. Location along line, distance from line, center size, and pathogen(s) were recorded.

From the data collected in prism plots, mean basal area, number of trees, and volume per acre were calculated by tree species, DBH class, and condition, including disease. Information on disease found both inside and outside of plots was used to construct a stand map indicating location of disease centers.

Disease

Root disease symptoms on infected living trees can include chlorotic and/or thinning foliage, an abnormal "distress" cone crop, recent reduced height growth, and resin flow at the base of the bole. Mortality usually occurs following several years of infection.

Laminated root rot, caused by the fungus *Phellinus (Poria) weirii*, is identified on living or recently killed trees by exposing the surface of portions of one or more major roots and observing the presence of ectotrophic mycelium, a light brown fungal growth (Plate 1). Dead trees are often windthrown, having a "root ball" due to decay of the root system. Laminated decay can usually be seen along with pitted wood and setal hyphae, characteristics of this disease (Plate 2).

Armillaria root rot, caused by the fungus *Armillaria mellea*, can be identified on an infected tree by removing a section of bark on a main root or at the root collar and exposing the cream-white colored mycelial fans (Plate 3). These can also be found on trees which have been dead less than 2 to 3 years. Trees killed by *A. mellea* may either be windthrown or remain standing for a time. Wood decay is spongy-yellow with characteristic black zone lines. Black rhizomorphs, infective string-like strands, are also sometimes found under the bark or along the exterior of roots.

Black stain root disease, caused by *Ceratocystis wageneri*, is not a root rot like the other diseases mentioned. This pathogen does not decay roots, but rather interferes with photosynthate and water transport. Trees within infection centers will usually remain standing for several years after they die. Diagnosis of this disease can be made by cutting into the sapwood of the root collar above an infected root or into the root itself and observing a black to chocolate-brown stain (Plate 4).

Root diseases are most often found and most damaging where they affect groups of trees. *A. mellea* and *P. weirii* mortality centers are usually focused around old infected stumps and root systems of the previous stand which can harbor the fungi for up to 50 years. These fungi will spread from this material to susceptible roots at the point of contacts. These fungi can then spread from tree to tree, expanding the center. Dead, windthrown trees can usually be found in the middle of these centers with standing dead and live symptomatic trees around the perimeter. Vine maple *(Acer circinatum)* will often grow in the center of these pockets.

Plate 1. Ectotrophic mycelium of *Phellinus (Poria) weirii* growing on Douglas-fir roots

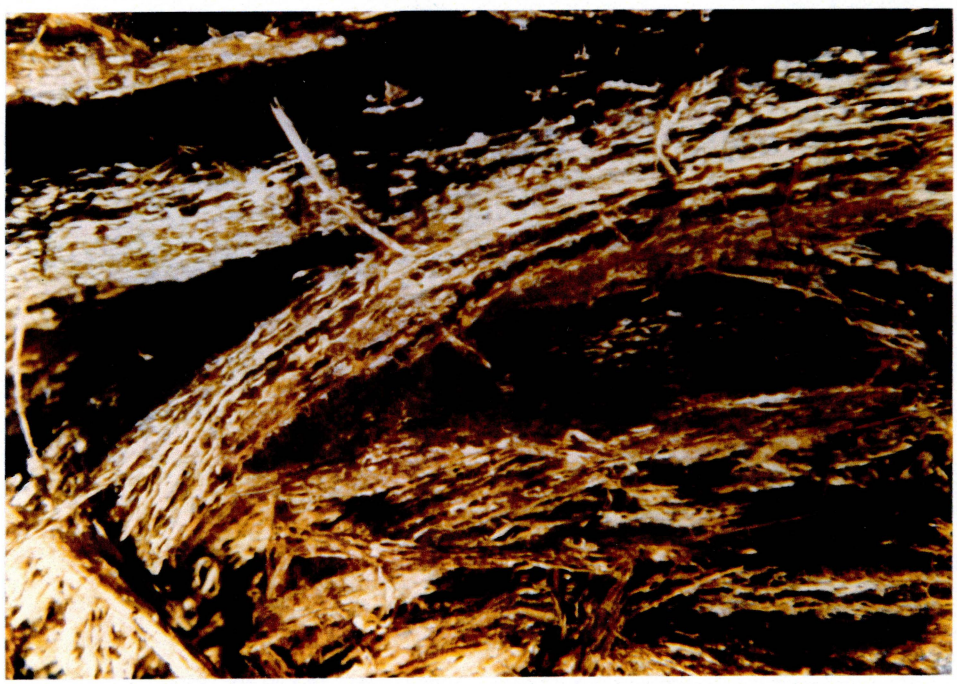


Plate 2. Laminated decay and setal hyphae characteristic of *Phellinus (Poria) weirii*.

Plate 3. Mycelial fans characteristic of *Armillaria mellea* on Douglas-fir

Plate 4. Black stained sapwood characteristic of *Ceratocystis wageneri*

Black stain root disease can spread similarly to laminated and Armillaria root rots, but insect vectors play a role in initiating infection and possibly some long-distance spread. Observations in many second-growth West Side Douglas-fir stands indicate that black stain usually becomes initially established in trees along roads, skid trails, fire lines, and other disturbed sites, especially in thinned stands. Once the fungus is introduced into these trees, it will then spread back into the stand via root contacts.

Results

Laminated root rot-caused mortality resulted in the loss of 0.4 percent (0.4 $ft.^2$) of the total basal area per acre. Another 0.6 percent (0.7 $ft.^2$) of the basal area was in live, infected trees (Table 1). This estimate for live infected trees is probably low since only symptomatic trees were checked.

Armillaria root rot-caused mortality has resulted in the loss of 0.5 percent (0.6 $ft.^2$) of the total basal area per acre. No live infected trees were identified in the cruise plots.

Black stain root disease-caused mortality has resulted in the loss of 0.4 percent (0.4 $ft.^2$) of the total basal area per acre and another 0.2 percent (0.2 $ft.^2$) in live infected trees.

Disease loss data in dead trees and probable near future losses represented by live infected trees are presented in Tables 2 and 3. All diseases occurred in Douglas-fir. Western hemlock was not found to be suffering from root diseases.

The occurrence and frequency of diseases are shown in Figures 2a and 2b. The majority of the root disease was found in the north portion of the survey block. Only one diseased tree with *C. wageneri* was found in the older unthinned stand (Figure 2b).

The survey block contained an average of 112.4 $ft.^2$ basal area per acre including live and dead trees (Table 4). Of this, 93.6 percent (105.2 $ft.^2$) was Douglas-fir and 6.4 percent (7.2 $ft.^2$) was western hemlock.

Stocking of trees greater than or equal to 4.0 inches DBH (Table 5) averaged 361.7 trees per acre. Of these trees, 94.2 percent (340.9) was Douglas-fir and 5.8 percent (20.8) was western hemlock. Average total volume per acre for the block was 2,536 $ft.^3$ (Table 6).

Discussion

Root diseases are serious problems in portions of the survey block even though the present losses indicated by the disease cruise are relatively small. The majority of the stand area is healthy but the numerous small disease centers will enlarge. Disease centers will be unstocked or understocked oftentimes with past mortality being unidentifiable. These losses are not represented in the cruise, but infection areas appear on the disease maps (Figures 2a and 2b). Most of the mortality is occurring in three main areas.

Armillaria root rot is most prevalent on 5 acres in the east-central section of the stand (Figures 2a and 2b). The occurrence of mortality may have been accentuated by use of off-site planting stock. Off-site planting stock seems

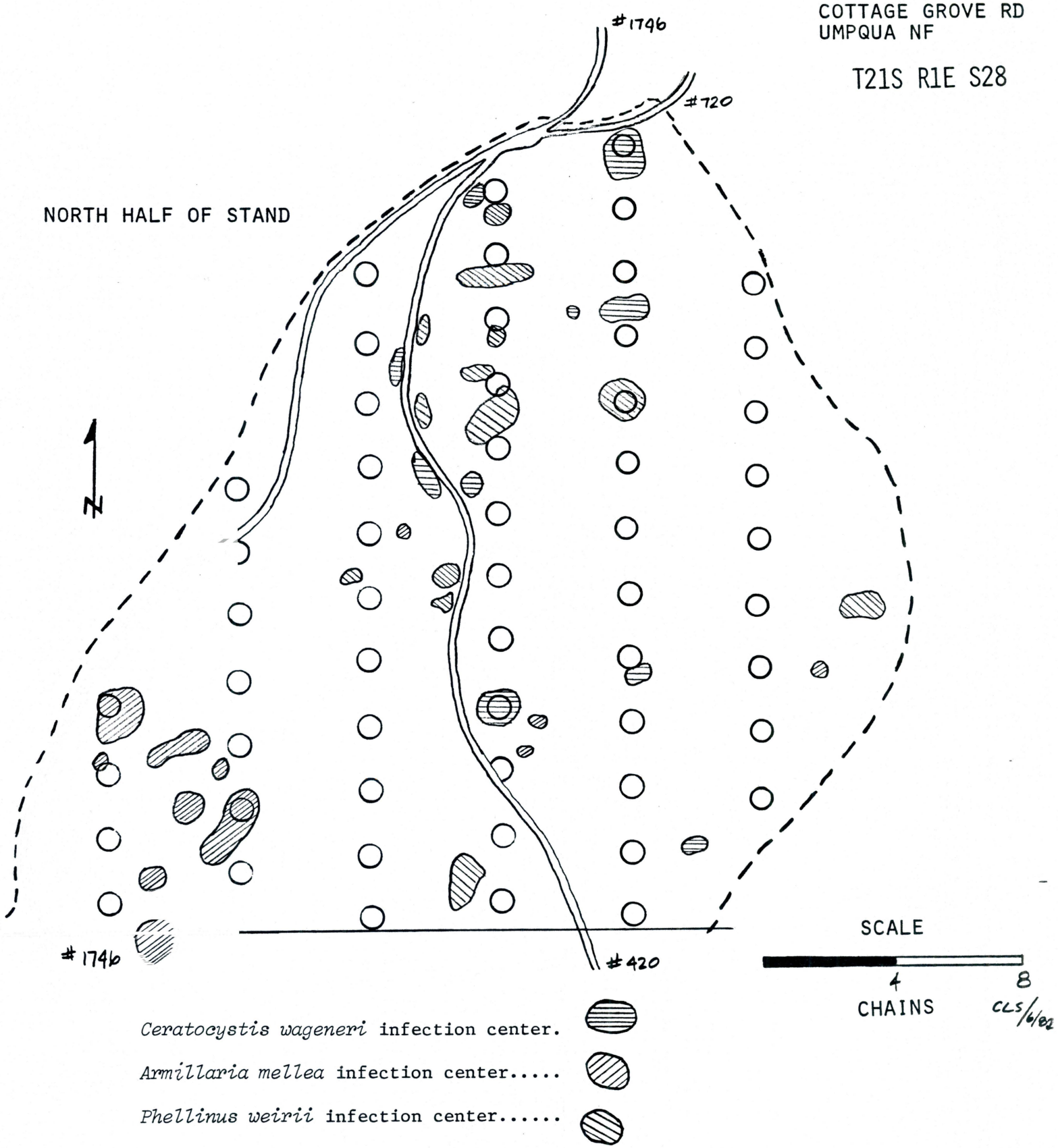


Figure 2a. Distribution of root disease in the survey block (Dinner Compartment-Cells 92, 96, 112). Circles indicate location of cruise plots.

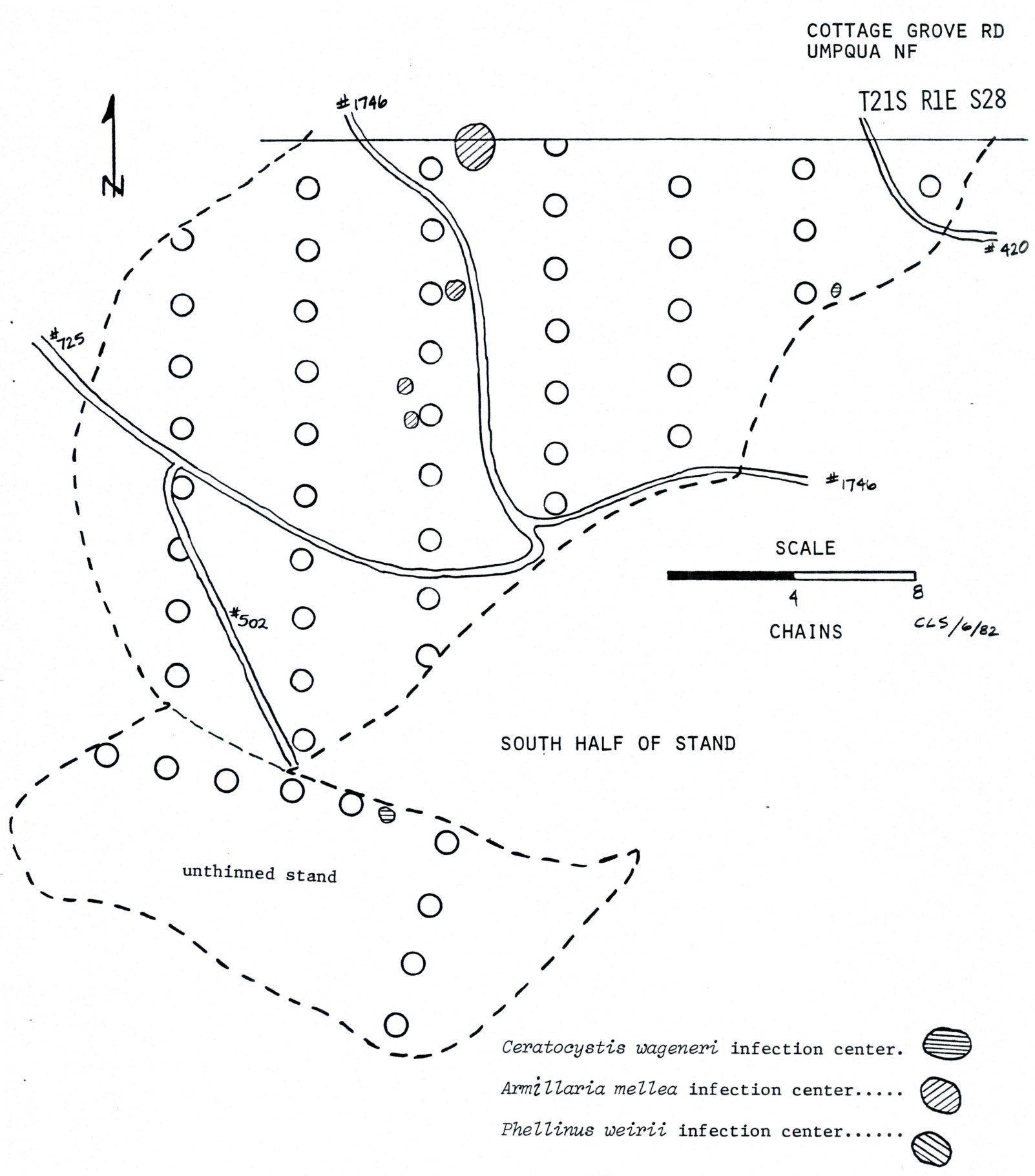


Figure 2b. Distribution of root disease in the survey block (Dinner Compartment-Cells 92, 96, 112). Circles indicate location of cruise plots.

to be more susceptible to Armillaria root rot damage than local stock. A large number of recently killed and live symptomatic trees around the perimeter of centers in this area indicates that this disease has spread relatively quickly. Trees being infected by *A. mellea* exhibited an unusual amount of basal resin flow and interbark mycelial fan formation, indicating tree resistance to attack. These trees were dying, probably because the *A. mellea* was an especially virulent stain. Loss will probably continue for at least several more years judging from current appearances. Current knowledge of this disease in West Side Douglas-fir plantations planted with thrifty local stock indicates that some resistance usually occurs as trees get older (20-30 years). Since the stand is now 27 years old, increased resistance and declining rates of mortality should occur in the near future unless the stock is not adapted to the site; in which case losses will continue for several more years.

The buildup of *A. mellea*-infected material in this area will probably pose a hazard to any Douglas-fir replanted on the site including on-site stock if the site is not treated. This is because even normally resistant trees can be overwhelmed by high amounts of inoculum in the soil.

Options for managing Armillaria root rot-infected areas include: (1) Do nothing. Unless the trees are off-site, tree killing by Armillaria should slow and eventually stop. (2) Inoculum reduction - if tree killing continues, the fungus will probably persist in stumps and roots after the stand is harvested. Post-harvest treatments may be required to prevent unacceptable losses in the next rotation. The site could be treated by removing the infested stumps and roots during final harvest using heavy equipment. After treatment the site could be replanted with a preferred but disease-susceptible species. (3) Species manipulation - if damage continues, the site could be replanted with a species that was not affected such as western hemlock.

Laminated root rot is most common in the north-central portion of the survey block (Figures 2a and 2b). Trees will remain susceptible to this disease throughout this rotation. If left untreated, losses within this stand will continue to occur and probably at an increasing rate.

Recommended control for laminated root rot is to cut all susceptible hosts in disease centers and a 50-foot buffer around each and, (1) mechanically remove stumps and large roots from the soil; or (2) harvest trees in the center and 50-foot buffer and plant with less susceptible tree species.

Stump removal is an alternative where terrain is gentle and track-equipped machinery can be used. This could be done in conjunction with a commercial thin entry. Mechanical removal is, however, expensive and may contribute to soil damage. Species manipulation is probably a more desirable alternative.

In the Dinner Compartment, tree species suited to the site by decreasing degree of susceptibility to *P. weirii* are: Immune-hardwoods (red alder, *Alnus rubra*, big leaf maple, *Acer macrophyllum*); resistant-western redcedar; tolerant-western white pine *(Pinus monticola)*; intermediately susceptible-western hemlock; susceptible-Douglas-fir. If only immune species are grown for a rotation (at least 40 years) on an infected site, inoculum in the soil should be sufficiently decayed to be noninfective. Douglas-fir could then be grown during the following rotation without becoming infected. If resistant or

tolerant species are grown, there may be a small amount of infection and retention of the pathogen, but virtually no mortality. If intermediately susceptible species are used, many trees may become infected. They could suffer some butt rot and mortality, and the disease will be maintained on the site. A subsequent rotation of Douglas-fir could possibly sustain significant losses. Replanting the site immediately with Douglas-fir would, in all likelihood, result in losses greater than those currently being experienced.

In the survey block the majority of black stain was found along currently used and abandoned roads. The disease appears to have spread relatively slowly within individual centers. Mortality seems to be subsiding.

Control of black stain root disease requires complete cutting of the affected host species within a center and 30-foot buffer zone. Slash should be piled and burned as soon as possible to minimize the chance of insects spreading the disease. Unlike most root-rotting fungi, *C. wageneri* does not exist as a saprophyte in dead material. Thus, removal of dead stumps and roots is not required to eliminate the infection potential when replanting susceptible hosts on the site.

Management Recommendations and Alternatives

Three different root diseases are present in the survey block. Because the root diseases are generally in different areas (Figures 2a and 2b), recommendations to minimize future losses will deal with each of these diseases separately.

Armillaria Root Rot

The portion of this block infected with Armillaria root rot need not receive any special management treatment at this time. Natural resistance should be developing and losses soon should begin to lessen unless the trees are offsite. Prior to the scheduled commercial thinning at age 40, the condition of this area should be reassessed. If losses have continued to occur, a clearcut may be needed in the diseased area. The site could then be planted or allowed to naturally regenerate with a species which will exhibit lower losses such as western hemlock. Stump removal and replanting with Douglas-fir would be another option. Although expensive, it would remove the inoculum from the site and allow the preferred species to be grown.

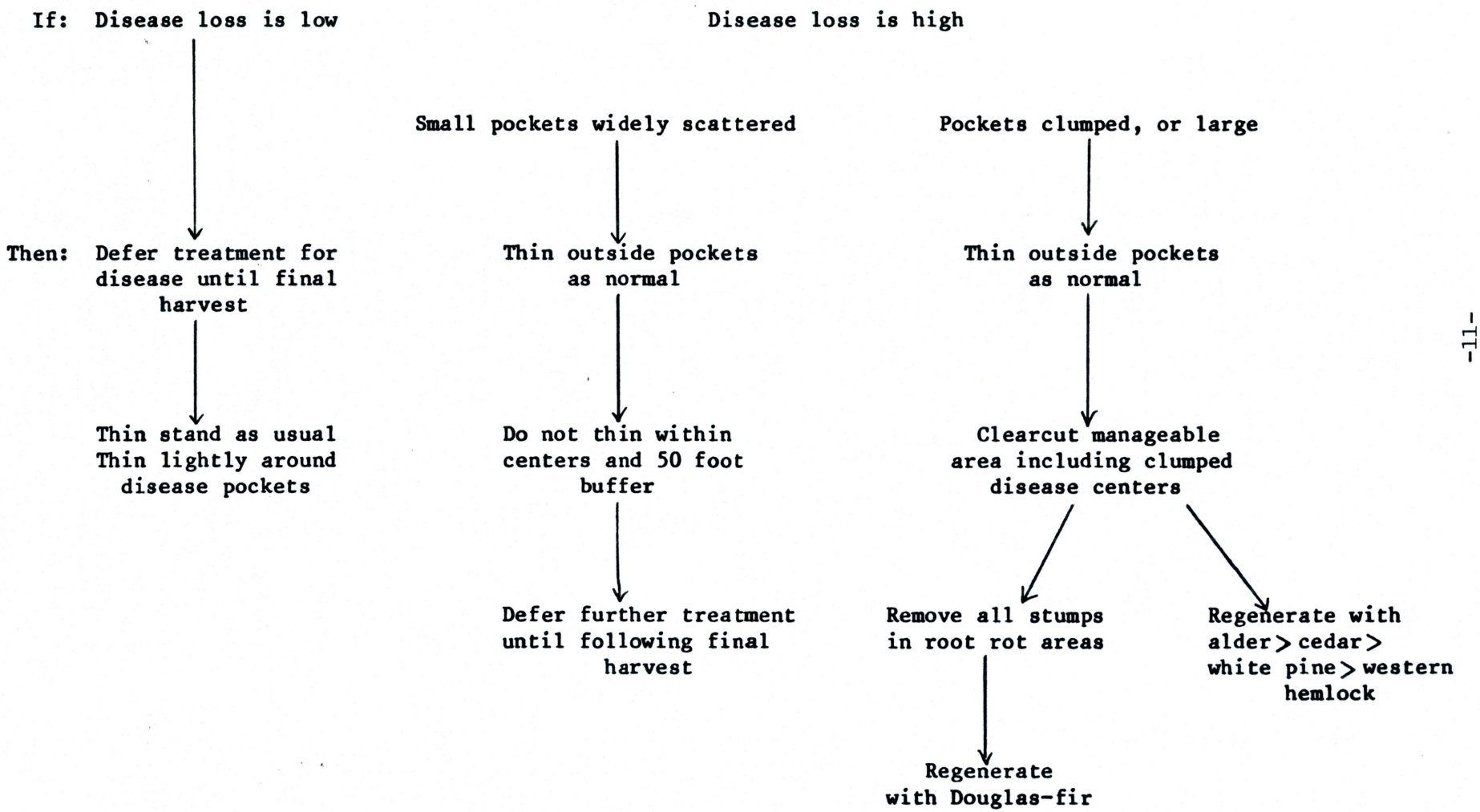
If losses abate between now and the scheduled commercial thinning, the diseased stand can be included in the thin, and the stocking level at that time will dictate how many trees, if any, are removed. Stump removal may be required following final harvest if infective material is still in the soil and Douglas-fir is the desired species in the following rotation. Another less susceptible species could be grown if stump removal is not done.

Laminated Root Rot

The area infected with laminated root rot also should have management deferred, at least until the planned commercial entry. At that time, a decision should be made to either treat the disease at that entry or defer major disease control until the final entry (Figure 3). This decision should be based on mortality rates and losses projected to rotation age. If losses are not severe

FIGURE 3. RECOMMENDATIONS FLOW CHART

COMMERCIAL THIN ENTRY (1995)


If: Disease loss is low
Disease loss is high
Small pockets widely scattered
Pockets clumped, or large
Then: Defer treatment for disease until final harvest
Thin outside pockets as normal
Thin outside pockets as normal
Thin stand as usual
Thin lightly around disease pockets
Do not thin within centers and 50 foot buffer
Clearcut manageable area including clumped disease centers
Defer further treatment until following final harvest
Remove all stumps in root rot areas
Regenerate with alder > cedar > white pine > western hemlock
Regenerate with Douglas-fir

at the time of the scheduled commercial thinning, unaffected portions of the stand could be thinned as usual. There should be no thinning within 50 feet of laminated root rot centers. Management for disease control would probably be preferable at the final entry. If this decision is made, two options are available. With the first, if Douglas-fir is desired, each disease center should be marked along with a 50-foot buffer strip at the time of clearcutting, and the stumps and major roots removed. Uprooted material can either be left on the surface or piled and burned. This site could then be replanted with Douglas-fir. The second option would be clearcutting, then planting with an immune, resistant, or tolerant tree species (red alder, western redcedar, possibly rust-resistant western white pine and lastly western hemlock are adapted to the site and would be preferred choices). Subsequent thinning should discriminate against volunteer Douglas-firs if this second option is selected.

Black Stain Root Disease

Black stain root disease seems to be subsiding. Unless activity by this disease increases, no special action is warranted other than monitoring. If black stain root disease increases again, the diseased areas could be treated by cutting all trees within the center and a 30-foot buffer strip. The slash should be piled and burned; then the site replanted with Douglas-fir.

Table 1.--Mean Basal Area Per Acre ($Ft.^2$) by Disease, Condition, and Diameter Class, Dinner Cells 92, 96, and 112.

DBH Class	Living Diseased Trees With: *Phellinus weirii*	*Armillaria mellea*	*Ceratocystis wageneri*	Dead Trees With: *Phellinus weirii*	*Armillaria mellea*	*Ceratocystis wageneri*	
4							
6				0.2	0.4		
8			0.2	0.2	0.2	0.2	
10	0.7					0.2	
12							
14							
16							
18							
Totals	0.7		0.2	0.4	0.6	0.4	
Grand Total							2.3

Table 2.--Mean Number of Trees Per Acre by Disease, Condition, and Diameter Class, Dinner Cells 92, 96, and 112.

DBH Class	Living Diseased Trees With: *Phellinus weirii*	*Armillaria mellea*	*Ceratocystis wageneri*	Dead Trees With: *Phellinus weirii*	*Armillaria mellea*	*Ceratocystis wageneri*	
4							
6				0.9	1.9		
8			0.5	0.5	0.5	0.5	
10	1.3						
12							
14							
16							
Total	1.3		0.5	1.4	1.4	0.8	
Grand Total							5.4

Table 3.--Mean Volume Per Acre by Disease, Condition, and Diameter Class, Dinner Cells 92, 96, and 112.

DBH Class	Living Diseased Trees With: *Phellinus weirii*	*Armillaria mellea*	*Ceratocystis wageneri*	Dead Trees With: *Phellinus weirii*	*Armillaria mellea*	*Ceratocystis wageneri*	
4							
6				6	3		
8			4	4	4	4	
10	14					4	
12							
14							
16							
18							
Total	14		4	10	7	8	
Grand Total							43

Table 4.--Mean Basal Area Per Acre ($Ft.^2$) by Tree Species, Condition, and Diameter Class, Dinner Cells 92, 96, and 112.

DBH Class	Douglas-fir Live	Douglas-fir Dead	Western Hemlock Live	Western Hemlock Dead	
4	7.3				
6	18.2	0.7	0.9		
8	32.7	0.7	0.9		
10	23.6	0.2	2.7		
12	12.7		1.8		
14	7.27				
16	1.8				
18			0.9		
Total	103.6	1.6	7.2	-0-	
Grand Total					112.4

Table 5.--Mean Number of Trees Per Acre by Species, Condition, and Diameter Class, Dinner Cells 92, 96, and 112.

DBH Class	Douglas-fir Live	Douglas-fir Dead	Western Hemlock Live	Western Hemlock Dead	
4	83.3		-0-		
6	92.6	3.8	10.4		
8	91.2	2.1	2.6		
10	43.3	0.3	5.0		
12	16.2		2.3		
14	6.8				
16	1.3				
18	-0-		0.5		
Totals	334.7	6.2	20.8	-0-	
Grand Total					361.7

Table 6.--Mean Volume Per Acre ($Ft.^3$) by Species, Condition, and Diameter Class, Dinner Cells 92, 96, and 112.

DBH Class	Douglas-fir Live	Douglas-fir Dead	Western Hemlock Live	Western Hemlock Dead	
4	108				
6	343	14	31		
8	711	16	18		
10	615	4	55		
12	324		44		
14	181				
16	44				
18	-0-		28		
20	-0-				
Totals	2,326	34	176	-0-	
Grand Total					2,536

Prepared by: Craig L. Schmitt
CRAIG L. SCHMITT, Plant Pathologist, FPM

9/22/82
Date

Prepared by: Alan Kanaskie
ALAN KANASKIE, Biological Technician, FPM

9-22-82
Date

Reviewed by: James S. Hadfield
JAMES S. HADFIELD, Supervisory Pathologist, FPM

9/22/82
Date

Approved by: Randall Buffam, Acting
PAUL E. BUFFAM, Director, FPM

9/22/82
Date